NEURAL INFIXATION.[1]

By R. HARVEY REED, M.D.,

OF COLUMBUS, OHIO,

PROFESSOR OF THE PRINCIPLES AND PRACTICE OF SURGERY AND CLINICAL SURGERY, OHIO MEDICAL UNIVERSITY, SURGEON TO THE PROTESTANT HOSPITAL.

BY the term neural infixation I mean the implanting or engrafting of one nerve into the other.

Whilst based on the same physiological principles as those which govern the suturing of nerves, I am inclined to the belief that there are other factors which enter into neural infixation that do not necessarily accompany nerve suturing.

I am greatly indebted to Professor G. Carl Huber, of the University of Michigan, for two very interesting reprints,[2] in which was published a "Physiological, Histological, and Clinical Study of the Degeneration and Regeneration in Peripheral Nerve Fibres after Severance of their Connections with the Nerve Centres." The conclusions arrived at in these monographs embrace the combined experiments of Professors Howell and Huber. In addition to these reprints, Professor Huber has very kindly given me additional data relative to nerve suturing up to the present date, and has very generously allowed me to use, in this paper, extracts of the text of a paper which he is now preparing on this subject.

In these experiments, conducted by Professors Howell and Huber, it was demonstrated that whenever a nerve is cut, the peripheral part undergoes degeneration. In this degeneration the axis cylinder is involved together with the medullary sheath. They were led to believe that such a thing as primary union without degeneration of the axis cylinder and medullary sheath did not and would not occur in either experimental work or surgical practice. They also arrived at the conclusion that the degenerated portion of the peripheral nerve was regenerated by the downward-growing axis cylinder of the central stump. In a communication received from Professor Huber, under date of March 26, he says, " As far as we could make out, there was no regeneration of the peripheral stump unless it was sutured to the central stump, or unless means were provided for the down-growing central axis cylinder to reach the peripheral stump."

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[1] A paper read before the Ohio State Medical Society at its Fiftieth Anniversary, held at Columbus, Ohio, May 15, 16, and 17, 1895.

[2] Journal of Physiology, Vol. XIII, No. 5, and Vol. XIV, No. I.

So-called nerve-grafting was performed as early as 1872 by Letievant, of France, to which I shall refer later on in this paper.

The reprint above referred to credits Flourins with having cut the two principal trunks of the brachial plexus in the fowl, putting one to the upper and one to the lower surface of the wing. The ends were then cross-sutured. After some months the bird regained the use of its wings, and mechanical stimulation of the central end of the nerve-trunk caused movements of the muscles of the lower surface of the wing, and *vice versa.*

A study of the experimental work of these eminent physiological experimenters and observers is quite sufficient to demonstrate that nerve suturing is not only possible, but practicable.

Without taking up further time in the study of the physiological and histological changes that take place in nerves after section or excision, I will proceed to consider, briefly, from a clinical stand-point, a slightly different form of the same class of cases.

In the research made on this subject I have been unable to find any one who has, either experimentally or otherwise, performed the operation of neural infixation after the method introduced by Dr. W. J. Galbraith, of Omaha, Neb. The doctor's method is intended to prevent paralysis when a section of the nerve has been destroyed, by accident or otherwise, where the gap between the central and peripheral ends is so great that it cannot be sutured, or bridged across with catgut, or tunnelled over with a tube of decalcified bone. Under these circumstances the doctor has demonstrated by his case that the central end of a nerve can be implanted into a parallel nerve at a certain point, and two or three inches lower down the peripheral end can be infixed into the same nerve, and that the impressions of the injured nerve will be carried through the section of the parallel nerve, from the central end to the peripheral end of the injured nerve, and *vice versa*.

The question will no doubt arise as to why the peripheral end of the injured nerve does not undergo degeneration, which has been so lucidly described by Howell and Huber, in both direct and indirect nerve suturing, or if it does undergo degeneration, how shall we account for its regeneration and the return of its normal functions?

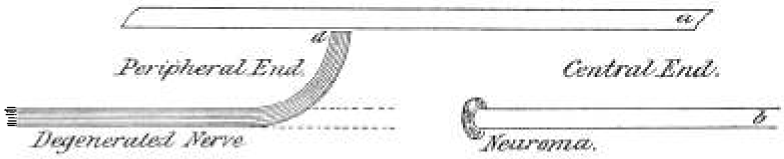

FIG. 1.—Nerve-grafting, according to Letievant.

By referring to the case of the French surgeon, Letievant, we find that the central end (Fig. 1) was not implanted into the healthy parallel nerve, but only the peripheral end was infixed, and the result was a bulb or neuroma formed at the central end, and degeneration of the peripheral end was a natural consequence. It only requires a glance to observe that there was no connection between the central and peripheral ends of this nerve, consequently it is not surprising that these unfavorable results followed.

Professor Huber, in conducting the experiments on cross-suturing (Fig. 2), cut the parallel nerves (*a* and *b*, Fig. 1). He excised a portion of *a* and engrafted the central end of it into the central end of *b*. He at the same time shortened the peripheral end *b* and engrafted it into the peripheral end of *a*. He then sutured the peripheral end of *a* and the central end of *b* together. (Fig. 3.) The results of his experiments, as will be shown by his paper which he is now preparing, and which he has very kindly permitted me to use, are as follows: A bulb or neuroma formed on the central end of *a*, whilst the peripheral end of *b* degenerated. The central end of *b* united with the peripheral end of *a*, through which nerve the impressions were conducted.

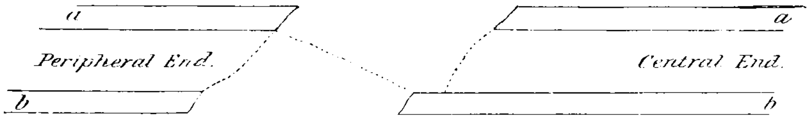

FIG. 2.—Nerve-grafting according to Huber, showing nerves cut ready for implantation.

This experiment corroborated the results obtained by Letievant. It will be observed that Professor Huber in his experiments "broke the circuit," so to speak, of both nerves, *a* and *b*. By his method of cross-suturing he required the impressions of central *a* to pass through a part of central *b*, across the point of suture, before they could reach the peripheral end of nerve *a*. In a similar manner the nerve impressions of central *b* must cross the point of suture and be transmitted through a part of the peripheral end of the nerve *a* before they reach the peripheral end of *b*. At the same time the peripheral end of nerve *b* is practically isolated from the central ends of both *a* and *b*, and is attached to the peripheral end of nerve *a* which has also been cut, and the legitimate consequences are that the peripheral end of nerve *b* undergoes degeneration.

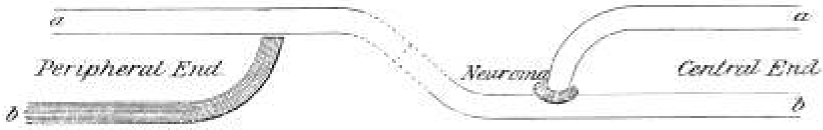

FIG. 3.—Nerve-grafting by cross-suturing, according to Huber.

By the following explanation and diagram, it will be observed that the operation performed by Galbraith is essentially different from either of those performed by Letievant or Professor Huber. To illustrate Dr. Galbraith's operation, we have parallel nerves (*a* and *b*, Fig. 4). Nerve *b* received an injury and the portion represented by the dotted lines is excised, leaving a gap too wide to be sutured or bridged across in any way. By Galbraith's operation, the peripheral end of *b* is infixed into the peripheral end of the uninjured nerve *a*, and the central end of *b* is implanted into the central end of *a*. The results, as shown by Dr. Galbraith, and more recently by Dr. Means, of this city, and by the case detailed in the present paper, where the same operation was performed, were all quite satisfactory, showing that where this operation is performed, the nerve impressions are carried from the central end of *b* through a part of *a* until they reach the peripheral end of *b*, and from there on to its extremity. (Fig. 5.)

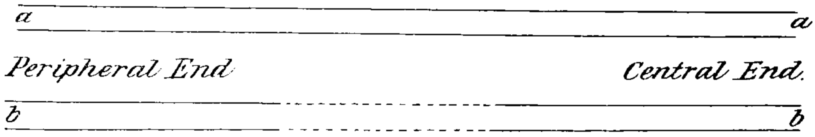

FIG. 4.—Nerves ready for infixation after the method of Galbraith.

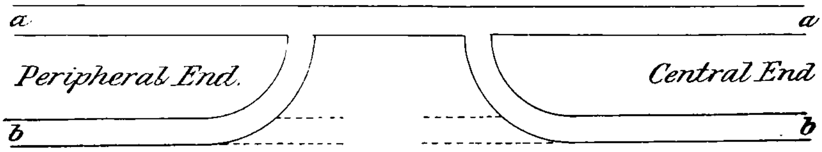

FIG. 5.—Neural infixation after the method of Galbraith.

In harmony with the experiments of Professor Huber, we would not expect the central end of *b* to undergo degeneration, but, instead, it becomes engrafted into the uninjured nerve *a*, and instead of the peripheral end of *b* becoming degenerated and remaining so, it receives nourishment from the uninjured nerve *a*, and if degenerated becomes regenerated and takes on its normal functions, and the result is that the nerve impressions of central *b* are transmitted through a portion of *a* until they reach the peripheral end of *b*, and from there they are carried to the extreme filaments of the nerve.

A patient was admitted to the Protestant Hospital the latter part of December, 1894, for tubercular adenitis involving the axillary glands. There was a large tumor in the left axillary region, nearly the size of a fist, extending to the humeral insertion of the pectoralis major muscle, backward to the serratus magnus and filling the entire axillary space. He was operated on December 28, 1894, and the tumor carefully dissected out, exposing the brachial artery, the axillary vein, and the brachial plexus of the nerves. In spite of all the care possible, we were obliged, during the operation, to cut the circumflex nerve and also the posterior thoracic, which we sutured with catgut. In addition to these we found a large muscular branch which supplied the inner portion of the arm which was given off from the posterior cord more than an inch above the circumflex and was entangled in the tumor to such an extent that it was necessary to excise at least two inches of it; the central end of this nerve was infixed into the central end of the circumflex, while the peripheral end was also carefully infixed with catgut suture into the central end of the circumflex. The cavity was packed with iodoform gauze and the dressing completed in the ordinary aseptic manner.

This operation was witnessed by quite a number of the local physicians as well as a large number of students. The next day I found there was paralysis of the deltoid muscle, together with anæsthesia and paralysis of the inner portion of the arm, extending down the ulnar side to the wrist. There was also anæsthesia found over the territory supplied by the posterior thoracic nerve. For more than a week the nerves were plainly visible in the axillary space when the dressings were changed, but were gradually covered by granulation tissue, and in about two weeks the functions of the severed nerves began to return. He was discharged from the hospital in three weeks and allowed to go home and return for dressing, and was finally discharged in eight weeks, and in nine weeks returned to his occupation as bartender. The patient is now entirely well.

I am well aware that the time elapsing between the operation and recovery is much shorter than that required in the experiments of Professors Howell and Huber. At the same time, there is no question as to the injury of the nerves as above stated, in this patient, while the time required for recovery corresponds with that in the cases of Drs. Galbraith and Means.

I shall not attempt, at this time at least, to explain from a physiological stand-point the regenerative process which took place, but will simply offer the case as a clinical fact, showing the results of nerve suturing and neural infixation. I feel justified, however, in saying that if future work in this direction proves as successful as the scanty experience of the past, it will enable the surgeon to relieve many injuries to the nerves which heretofore have remained permanent.